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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

24 Feb 95

MEMORANDUM FOR 341 CES/CEVR
ATTN: Mr. Dan Duff
39 78th Street North
Malmstrom AFB MT 59402-7536

FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

SUBJECT: Completion of One-Year Bioventing Test, Bulk POL Storage Area, and Pumphouse 2

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation projects at the Bulk POL Storage Area and Pumphouse 2 have been completed. For each site, Figure 1 provides general site information and Table 1 provides a summary of initial, six-month, and one-year fuel biodegradation rates measured at several monitoring points. The one-year biodegradation rates for the POL Storage area are significant due to the amount of fuel residual at this active site. The one-year biodegradation rates at Pumphouse 2 could not be determined because the presence of a high water table prevented the collection of respiration samples. Parsons Engineering Science, our contractor, plans to conduct a respiration test while performing other work associated with our Risk-Based Approach Initiative. Table 2 provides a summary of initial and final soil and soil gas sampling results for total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX). Based on results from your sites and 123 other sites currently under operation, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend its application at other sites on your installation using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February, 1994. These are found in the "Tool Box" recently sent to your base.

The objective of the one-year sampling effort was not to collect the large number of samples required for statistical significance, but to show relative changes in TRPH and BTEX concentrations. The POL Storage Area soil sampling results indicate a one order of magnitude reduction in BTEX concentrations at MPA-3, MPB-5, and MPC-7. TRPH concentrations significantly decreased at MPA-3 and MPC-7, but increased at MPB-5. An increase in TRPH concentrations at MPB-5 could indicate a leak in the fuel lines adjacent to this monitoring point or soil sampling variability. Soil gas sampling results showed a significant reduction in TVH and BTEX at MPA-3.5, MPB-3.5 and MPC-7.

Pumphouse 2 soil sampling results indicate a one order of magnitude reduction in BTEX and TRPH concentrations at MPA-2, MPB-3.5, and MPC-5.5. Soil gas

AFMOI-03-0730

sampling results showed an order of magnitude reduction in TVH and BTEX at MPA-4 and MPB-4.

Soil gas samples are similar to composite samples in that they are collected over a wider area. Thus, they provide a good indication of changes in soil gas profiles and volatile contaminant concentrations (see Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural Attenuation Potential, February 1994). Soil samples, on the other hand, are discrete point samples subject to large variabilities over small distances/soil types. Given this variability, coupled with known sampling and analytical variabilities, a large number of samples would have to be collected to conclusively determine "real" changes in soil contamination. Because of the limited number of samples, these results should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. In-situ respiration tests are considered to be better indicators of hydrocarbon remediation than limited soil sampling.

Sampling results indicate that a reduction in TRPH has taken place in the soils within the estimated 25-foot treatment radius of the pilot vent wells at both sites. Due to the inherent variability of in-situ soil samples, TRPH sampling is inclusive at this time, but all other measurements indicate that fuel biodegradation is progressing at a significant rate.

AFCEE recommends that the bioventing pilot system continue to operate at the POL Storage Area until background respiration rates are approached. If additional source removal is required, system expansion to a full-scale bioventing system can be conducted through HQ AFCEE. We also recommend the bioventing pilot systems continue to operate at Pumphouse 2 until the Risk-Based Treatability Study results are known. If full scale source removal is required, system expansion to a full-scale bioventing system can be conducted through the Risk-Based Approach. Please contact Sam Taffinder, AFCEE/ERT, DSN 240-4366, COM 210-536-4366, to discuss the technical details for full-scale expansion.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. We strongly encourage its use over an arbitrary TPH standard. Within the AFCEE Risk-based Petroleum Hydrocarbon "Tool Box," the reported entitled "Use of Risk-based Standards for Cleanup of Petroleum Contaminated Soil" summarizes the BTEX/TPH issue and will assist you in negotiating for a BTEX cleanup standard. Our information indicates that Montana regulates to BTEX clean-up levels, but this decision is made in conjunction with the results from a risk evaluation on a site-by-site basis. In conclusion, a risk-based approach will expedite site closure while reducing overall costs.

In general, quantitative destruction of BTEX will occur over a one- to two-year bioventing period. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TPH cleanup is chosen, the pilot and full-

scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted four to six months after background respiration rates are approached.

Because these are streamlined test and evaluation projects, our contract does not provide for additional reports to the base on pilot study results. The interim results report dated Feb 93 contains as-builts and initial data. This letter summarizes all data collected and provides the next step recommendations. AFCEE is no longer responsible for the operation, maintenance, or monitoring of bioventing systems. We are initiating a contract to extend monitoring at some sites beyond the initial one-year test. Monitoring will include soil gas and respiration tests to document hydrocarbon degradation, but may also include the collection of sufficient final soil samples to statistically demonstrate site cleanup. If you are interested, please call us.

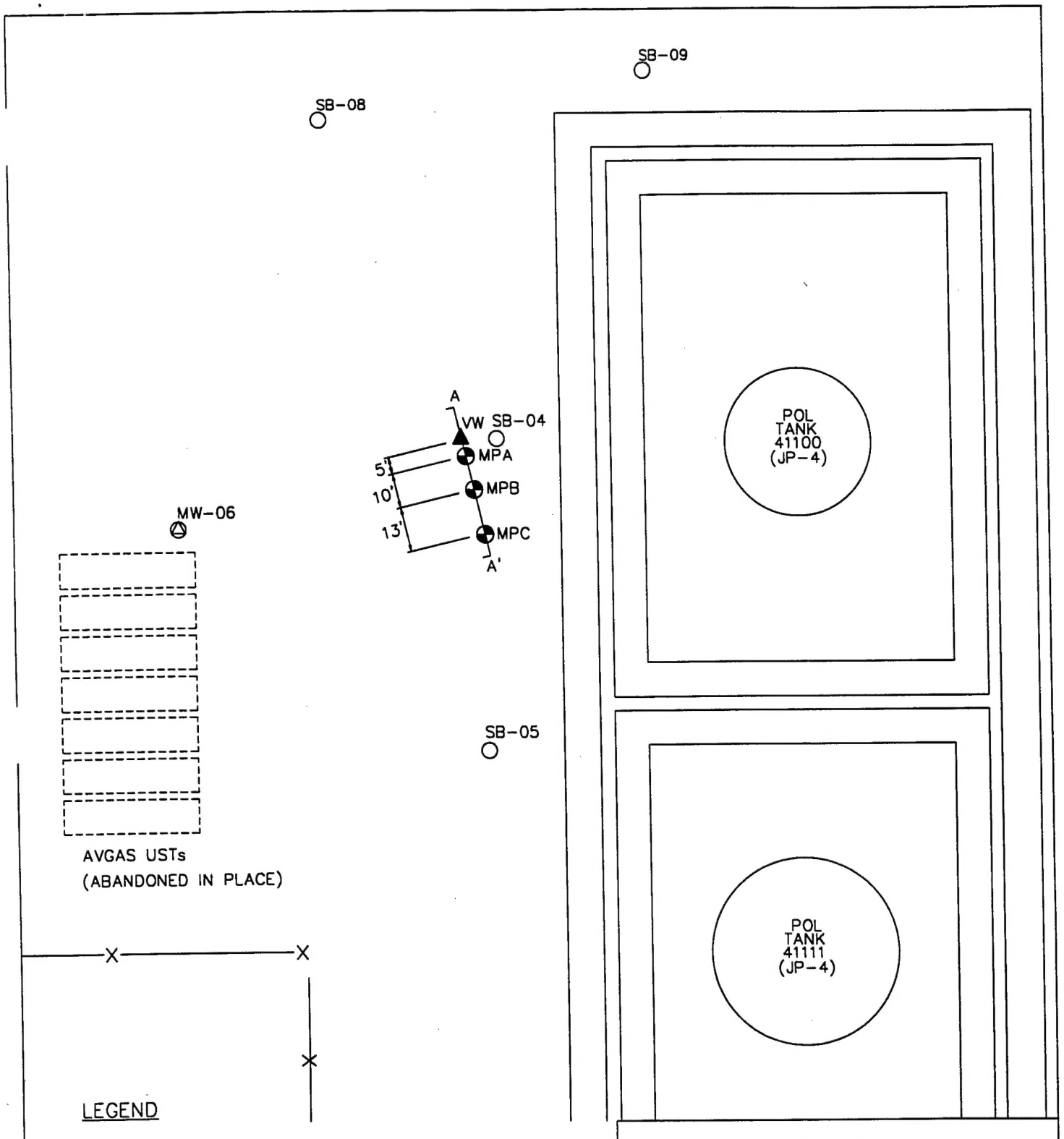
The blower and accessories are now base property and should continue to be used on these or other bioventing sites. Although current equipment is explosion proof, under no circumstances should it be used for soil vapor extraction unless appropriate explosion-proof wiring is provided. If the base does not want the keep the blower or if you have further questions, please contact us.

On behalf of the AFCEE/ERT staff, I would like to thank you for your support of these bioventing tests and evaluation projects. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other DOD, government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. POL Data
2. Pumphouse 2 Data
3. Survey

cc: HQ AFSPC/CEVR
AFCEE/ERD (Mr. McMindes)



NOTE:
LOCATIONS OF ALL WELLS AND SOIL BORINGS ARE APPROXIMATE.

FIGURE 1

AS-BUILT
VENT WELL AND
MONITORING POINT LOCATIONS
PS-4, BULK POL STORAGE AREA

Malmstrom AFB, Montana

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN0705, 11/10/93 at 15:05

TABLE 1
BULK POL STORAGE AREA
RESPIRATION AND DEGRADATION RATES
MALMSTROM AFB, MT

Location–Depth	Initial			6–Month[b/]			1–Year[d/]		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA–3.5	0.01	420	NS[c/]	0.0032	190	NS	NS[e/]	NS	NS
MPB–3.5	0.028	1100	NS	0.0074	450	NS	0.0042	300	NS
MPC–3.5	0.018	720	11.56	0.0066	400	NS	0.0041	290	11.89

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Assumes moisture content of the soil is average of initial and final moistures.
[c/] NS= Not sampled.
[d/] An area respiration test was performed by restarting the blower for approximately 47 hours to provide oxygen to soils.
[e/] MPA–3.5 was below the ground water suface at time of 1–year sampling.

TABLE 2
BULK POL STORAGE AREA
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
MALMSTROM AFB, MT

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	MPA-3.5		MPB-3.5		MPC-3.5	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	34,000	NS[d/]	49,000	1,100	54,000	52
Benzene (ppmv)	< 1.1	NS	< 2.8	< 0.018	< 1.8	< 0.12
Toluene (ppmv)	< 1.1	NS	< 2.8	< 0.018	34	< 0.12
Ethylbenzene (ppmv)	8.6	NS	14	0.590	12	3.500
Xylenes (ppmv)	21	NS	52	1.700	40	6.700

	MPA-3		MPB-5		MPC-7	
Soil Hydrocarbons	Initial[e/]	1-Year[f/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	3640	315	880	2440	3690	694
Benzene (mg/kg)	0.79	< 0.05	< 2.8	1.7	12	0.33
Toluene (mg/kg)	42	< 0.05	30	15	310	2.1
Ethylbenzene (mg/kg)	15	< 0.05	7.2	13	43	2.8
Xylenes (mg/kg)	84	< 0.099	45	66	240	13
Moisture (%)	18	16.3	12	16.6	21	15.2

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b/] Initial soil gas samples collected on 10/12/93.
[c/] 1-Year soil gas samples collected on 10/19/94.
[d/] NS = Not sampled, monitoring point below water surface.
[e/] Initial soil samples collected on 10/11/93.
[f/] 1-Year soil samples collected on 11/9/94.

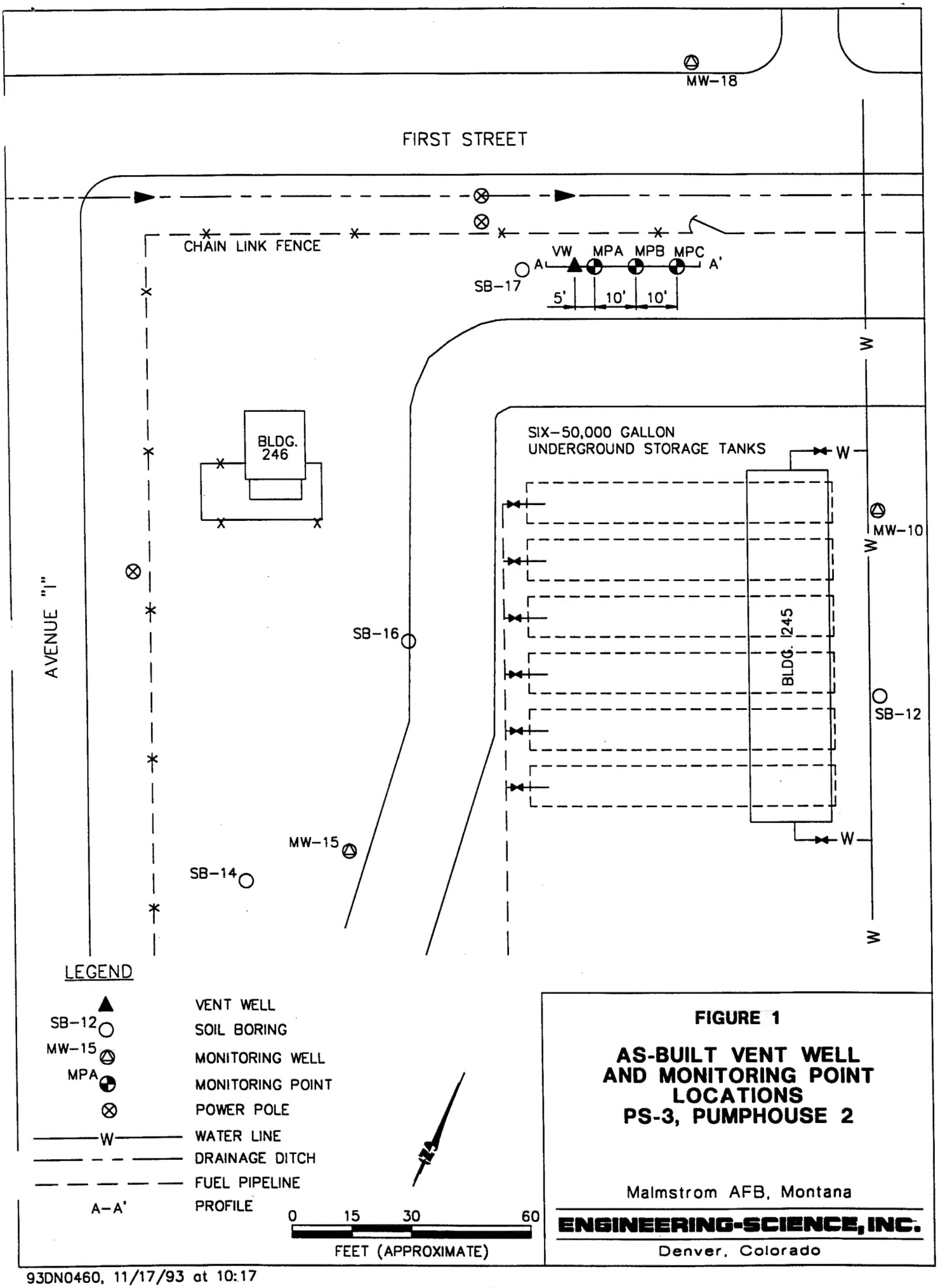


FIGURE 1

AS-BUILT VENT WELL AND MONITORING POINT LOCATIONS PS-3, PUMPHOUSE 2

Malmstrom AFB, Montana

ENGINEERING-SCIENCE, INC.

Denver, Colorado

93DN0460, 11/17/93 at 10:17

TABLE 1
PUMPHOUSE 2
RESPIRATION AND DEGRADATION RATES
MALMSTROM AFB, MT

Location–Depth	Initial			6–Month			1–Year[b/]		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA–4	0.049	2100	16.9	0.0051	220	NS	NS	NS	16.4
MPB–4	0.05	2600	NS[c/]	0.0034	180	NS	NS	NS	NS
MPC–4	0.063	5300	NS	0.0058	490	NS	NS	NS	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] The 1 year respiration tests were not performed due to monitoring point flooding. All points were below the ground water surface.
[c/] NS = Not sampled.

TABLE 2
PUMPHOUSE 2
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
MALMSTROM AFB, MT

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	MPA-4		MPB-4		MPC-4	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	5,400	NS[d]	6,900	65	14,000	NS
Benzene (ppmv)	< 0.61	NS	< 0.69	< 0.002	19	NS
Toluene (ppmv)	< 0.61	NS	< 0.69	< 0.002	< 0.57	NS
Ethylbenzene (ppmv)	9	NS	5.2	0.150	13	NS
Xylenes (ppmv)	11	NS	9.8	0.280	15	NS

	MPA-2		MPB-3.5		MPC-5.5	
Soil Hydrocarbons	Initial[e/]	1-Year[f/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	300	146	270	33.5	150	74.4
Benzene (mg/kg)	< 0.65	< 0.05	< 0.64	< 0.05	< 0.31	< 0.05
Toluene (mg/kg)	0.71	< 0.05	< 0.64	0.12	1.1	0.057
Ethylbenzene (mg/kg)	1.2	< 0.05	2.2	0.55	1.5	0.067
Xylenes (mg/kg)	3.6	< 0.1	3.1	0.29	4.4	< 0.1
Moisture (%)	23	NA[g]	22	NA	20	NA

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b/] Initial soil gas samples collected on 10/3/93.
[c/] 1-Year soil gas samples collected on 10/19/94.
[d/] NS = Not sampled.
[e/] Initial soil samples collected on 10/2/93.
[f/] 1-Year soil samples collected on 10/23/94.
[g/] NA = Not analyzed.